Hand in Rocket Lab
Thermal Equilibrium and Review for Test Feb 8

Thermal Equilibrium

recall: The heat absorbed or given off for a change in temperature can be calculated by

$Q=mc\Delta T$

c depends on the substance

You can see the big difference in specific heat capacities when you put different materials at different temperatures together. This way of measuring heat is called calorimetry. (Lab specific heat capacity Feb 13th)

eg. You put 50.0 g of an unknown metal at 100.0ºC (boiling point of water) into 100.0 g of water at 15.0ºC (tap water). You insulate the system so no energy escapes. After a bit of time, the water and the metal are at 20.0 ºC.

a) how much energy was given to the water to heat it from 15.0 to 20.0ºC?
b) What was the change in temperature of the metal?
c) If all the energy given to the water came from the

metal, what is the specific heat capacity of the metal?

d) If the same experiment was done with lead, c= 130J/kgºC, what would be the equilibrium temperature if 50.0g of lead at 100.0ºC was put in 100.0g of water at 15.0ºC?

Homework

Review Work and Energy:

p212-214 AC 1-7 odds, Problems 1, 4, 5, 16, 20,

p237-239 AC 1, 3, 5, 7, 13,

Problems 3, 8, 22, 29, Bonus: 31

a) how much energy was given to the water to heat it from 15.0 to 20.0ºC?

Q=mc(Tf-Ti) =

0.1000kgx4180J/kgK(20.0ºC-15.0ºC)

= 0.1x4180x5=2090 J

b) What was the change in temperature of the metal?

Tf-Ti = 20.0ºC-100.0ºC = -80.0ºC (watch the negative)

c) If all the energy given to the water came from the metal, what is the specific heat capacity of the metal?

heat lost by the metal = heat gained by water

$-Q_{metal} = Q_{water}$ watch the negative sign!!!!

$-m_{metal}c_{metal}(\Delta T_{metal}) = m_{water}c_{water}(\Delta T_{water})$

- 0.0500kg c (-80.0ºC) = 2090J

c = 2090/(0.05x80)=522.5= 522 J/kgºC

- 0.0500kg c (-80.0°C) = 2090J

c = 2090/(0.05x80)=522.5= 522 J/kg°C

d) If the same experiment was done with lead, c= 130J/kg°C, what would be the equilibrium temperature if 50.0g of lead at 100.0°C was put in 100.0g of water at 15.0°C?

heat lost by the metal = heat gained by water

$-Q_{metal} = Q_{water}$ watch the negative sign!!!!

$-m_{metal}c_{metal}(\Delta T_{metal}) = m_{water}c_{water}(\Delta T_{water})$

$-0.050kg(130J/kgK)(T_E - 100.0°C) =$

$0.100kg(4180J/kg°C)(T_E - 15.0°C)$

0.05x130=6.5

$-6.5T_E + (6.5x100) = 418T_E - (15x418)$

$650+(15x418)=6,920 = (418+6.5)\ T_E$

$T_E = 6920/424.5=16.3015$

$T_E =$ 16.3°C

(on the test/quiz if your equilibrium temperature of the water is lower than starting temperature, you forgot the negative sign, watch out!)

Thermal Equilibrium - When objects are at the same temperature, the equilibrium temperature T_E.

curling rocks!

a) $Ek = 1/2mv^2$ = 0.5x19.5x2^2=39 J or

0.5x19.5x4^2=156 J

b) work done by friction = -Ek -39J or -156J

c) F = W/d = -Ek/d -39/44=-0.8864 = -0.89 N or -156/44=-3.5455 = -3.5N

Block 2-4
Hand in Rocket Lab
Thermal Equilibrium and Review for Test Feb 8

Thermal Equilibrium

recall: The heat absorbed or given off, Q, for a change in temperature can be calculated by

$Q= mc\Delta T$
m is mass
T is temperature
c is the specific heat capacity - determined by the substance

Thermal Equilibrium - when two objects are put in contact, heat flows from the hot object to the cold object until they are at the same temperature, the equilibrium temperature, T_E.

eg. An unknown metal, 50.0g, is heated up to 100.0ºC in boiling water and then placed in 100.0g of water at 15.0ºC. If the system is perfectly insulated (no heat in/out) all then energy lost by the metal goes to the water. If they reach thermal equilibrium at 20.0ºC,

a) what is the heat absorbed by the water warming it from 15 to 20ºC? c=4180J/kgK
   Q=mc(Tf-Ti) = 0.100x4180x(20-15)=2090 J
b) What is the change in temperature of the unknown metal?
   ΔT = Tf-Ti = 20-100=-80 ºC
c) what is the specific heat capacity of the unknown metal?
   Heat lost by the metal = heat gained by water
   $-Q_{metal} = Q_{water}$
   -mc(Tf-Ti) = 2090J
   c = 2090/(0.05x80)=522.5 J/kgK = 522J/kgK

d) if the experiment was repeated but using 50.0g of lead(130J/kgK) at 100.0ºC placed in 100.0g of water at 15.0ºC, what is the equilibrium temperature? (algebra skillz) - lab Feb 13th
   $-Q_{lead} = Q_{water}$
   $-m_{lead}\, c_{lead}\, (T_E - T_i) = m_{water}\, c_{water}\, (T_E - T_i)$
   $-0.05 \times 130 \times (T_E - 100) = 0.1 \times 4180 (T_E - 15)$
   0.05x130=6.5

$-6.5T_E + 650 = 418T_E - (418x15) = -6,270$
6270+650=6920
418+6.5=424.5
$424.5T_E = 6920$
$T_E = 6920/424.5 = 16.3015 = 16.3ºC$

Review Work and Energy:
p212-214 AC 1-7 odds, Problems 1, 4, 5, 16, 20,
p237-239 AC 1, 3, 5, 7, 13,
Problems 3, 8, 22, 29, Bonus: 31

Quiz:

1.

a) m = Fg/g = 70N/9.8N/kg = 7.1kg or 50/9.8=5.1kg

b) W=Fd if F and d are in the same direction
fighting gravity W = 70N or 50N x 4.0 m up (ignore the sideways motion)
70x4=280 J or 50x4=200 J

c) gravity is pulling down, while displacement is up, so W is negative = -280 J or -200J

d) 0J because the force is perpendicular to d. (F is up but d is sideways)

e) P=W/t = (mxg + W)h/t (60x9.8+70)x4/5=526.4 W

(60x9.8+50)x4/5=510.4 W

f) IMA = din/dout 2 = din/4 din=8.0m

g) IMA = Fout/Fin -minimum Fin = 50 or 70/2
= 35N or 25N

h) MA = Fout/Fin actual = 50 or 70/40=1.75 or 50/30=
1.67

i) eff = wout/Win = 50 or 70 x4/40 or 30 x 8
50x4/(30x8)=0.8333 = 83% efficient
70x4/(40x8)=0.875 = 88% efficient

Q2
curling rocks!

a) Ek = 1/2mv^2 = 0.5x19.5x2^2=39 J or
0.5x19.5x4^2=156 J

b) work done by friction = -Ek -39J or -156J

c) F = W/d = -Ek/d -39/44=-0.8864 = -0.89 N or
-156/44=-3.5455 = -3.5N

Block 2-3
Hand in Rocket Lab
Thermal Equilibrium and Review for Test Feb 8

Thermal Equilibrium

recall: The heat absorbed or given off, Q, for a change in temperature can be calculated by

$Q=mc\Delta T$

m is mass, in kg
c is the specific heat capacity - determined by the material - in J/kgK or J/kgºC (same)
ΔT is change in temperature = $T_f - T_i$ in ºC or K

Thermal Equilibrium - If you put a hot object (coffee) in contact with a cold object (milk) heat transfers from the hot object to the cold one until they are at the same temperature, equilibrium temperature, T_E.

If everything is insulated, the heat lost by the hot object, $-Q_{hot}$ = heat gained by the cold object Q_{cold}

$-Q_{hot} = Q_{cold}$

$-mc(T_E-T_i) = mc(T_E-T_i)$

eg. An unknown metal, 50.0g, is heated up to 100.0ºC in boiling water and then placed in 100.0g of water at 15.0ºC. If the system is perfectly insulated (no heat in/out) all then energy lost by the metal goes to the water. If they reach thermal

equilibrium at 20.0ºC,

a) what is the heat absorbed by the water warming it from 15 to 20ºC? c=4180J/kgK
   Q= mc(Tf-Ti) = 0.10x4180x(20-15)=2090 J

b) What is the change in temperature of the unknown metal? ΔT = Tf-Ti = 20-100=-80 ºC

c) what is the specific heat capacity of the unknown metal?
   -mc(Tf-Ti) =Qwater
   c = Q/(-m(Tf-Ti)) = 2090/(-0.05x(-80))=522.5 J/kgK
   522J/kgºC

d) if the experiment was repeated but using 50.0g of lead(130J/kgK) at 100.0ºC placed in 100.0g of water at 15.0ºC, what is the equilibrium temperature? (algebra skillz) - lab Feb 13th

   $-Q_{hot} = Q_{cold}$

   $-mc(T_E-T_i) = mc(T_E-T_i)$

   -0.05x130=-6.5

   $-6.5T_E + 6.5x100 = 0.1x4180(TE - 15)$

   $-6.5T_E + 650 = 418T_E - 6270$

   $424.5T_E = 6920$

   $T_E = 6920/424.5=16.3015$

   T_E 16.3 ºC

Review Work and Energy:
p212-214 AC 1-7 odds, Problems 1, 4, 5, 16, 20,
p237-239 AC 1, 3, 5, 7, 13,
Problems 3, 8, 22, 29, Bonus: 31